STUDIES ON ORGANIC SOIL PROFILES I : METHODOLOGY AND ITS APPLICATION IN THE HULSHORSTERZAND

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Summary

In this paper the general context and characteristics of studies on organic soil profiles, as carried out by the University of Amsterdam are discussed.

First, attention is paid to the specific position and development of the organic profiles and the role of soil forming factors are described. The study has been carried out in five first generation Scots pine stands of increasing age 15, 30, 55, 90, and 130 years, all on recent drift sands without antecedent soil formation.

It was found that evident differences exist between soils within the chronosequence related to the various stands. Within the time-span the increase of thickness of the organic profile and differentiation between and development of new organic horizons together with development of new organic horizons together with development of a micropodsol are most prominent.

Keywords: Organic profiles, humus profiles, humus, sandy soils, Veluwe, Netherlands, multivariate analyses, Twinspan, succession, Pinus sylvestris, micropodsol.

Introduction

In the past, organic profiles (humus profiles) have long been neglected by pedologists, in particular in The Netherlands, although studies on humus and its role in plant nutrition and soil structure are old topics in soil science. However, it is increasingly understood that knowledge about their characteristics and genesis is essential for pedogenetic and ecological studies of non-agricultural soils.

Organic profiles hold a position, which is intermediate between mineral soil and edaphon. Its properties are strongly controlled by the input and characteristics of the biomass (litter) and by the soil fauna and flora. The system, as compared to mineral horizons, rapidly adapts to changes in conditions.

Research on organic profile development and its pedological implications is hindered by the fact that organic profiles, as observed in the field, largely owe their characteristics to processes active in the past. These processes were dependent on factors such as vegetation and drainage, which may have rapidly changed in time, as well as on the antecendent soil formation.

In general the number of factors and variables is too large to allow quantitative statements on the genesis and characteristics of organic profiles as dependent on substratum and vegetation. Such data are essential prerequisites for genetic classifications of soil profiles, applicable in the field.

The research of the FGBL of the UvA concentrates on the genesis of organic profiles as dependent on the factors parent material, time and vegetation, with the aim to develop a genetic classification. Our approach is to study field situations in which the number of variables is limited and all relevant factors are well known. This implies that the research is carried out on organic profiles, developed in recent parent materials, without relevant antecedent soil formation, with a vegetation of which management and age are exactly known and with a well defined hydrology.

Current research projects

Thus far four situations have been studied.

Hulshorsterzand (Central Veluwe): recent eolian sands of uniform composition with first generation Scots pine stands. The stands are of different age. The herbal layers in the stands represent a distinct veqetation succession.

Petrea (North Veluwe): pre-glacial sands of ice-pushed ridge. Variables are:
- vegetation differentiation in a thirteen years old natural vegetation;
- substratum characteristics, i.e. uniform parent material with a strongly disturbed podzol (variable antecendent soil characteristics).

Bremerbergbos (Oostelijk Flevoland): recently reclaimed polder, calcareous marine-lacustrine deposits. Only one variable:
- vegetation (plantations of Robusta and Balsem Poplar, 27 years old).

Lepelaarsplassen (Zuidelijk Flevoland): recently reclaimed polder, calcareous clays and sludge deposits under natural willow stands. Only one variable:
- parent material.

This paper deals with the research on organic profile development during the forest succession in the Hulshorsterzand area (Central Veluwe).

Data collecting and statistical approach

Both semi natural and planted forests in The Netherlands are divided into parcels and often one or two species are planted or sowed in one parcel. For decades this has been common practice in forestry. This means that one might expect uniform development of the organic profile under a uniform stand in one parcel. However, studies on organic profiles, like those in the Hulshorsterzand, face three major problems:
- variability in composition of the input of biomass produced by different trees and different herbal layers;
- variability in quantity of biomass input related to the distance of major litter sources (distance towards stem and canopy);
- variability in ecological conditions such as microclimate.

These together results in a high variability of organic profiles at microscale. This means that the study on the overall habitus of the organic profile under different vegetation types e.g. parcels with different stands and/or different species has to be carried out, using statistical methods.

In the Hulshorsterzand this approach was as follows:

In five first generation Scots pine stands of increasing age (15, 30, 55, 90, and 130 years), all on recent drift sands without antecedent soil formation, sites were selected at random. At these sites soil profiles were extensively described, using the Guidelines for Soil Profile Description (FAO/UNESCO, 1975) for the mineral profile and the system of Klinka et al. (1981) for the organic profile. Klinka's descriptive system is basically similar to that of the FAO/UNESCO. Vegetation at the sites was also recorded. Data of the organic profile were statistically analyzed, using standard methods as well as Twinspan, which is a computer-programme for multivariate analyses currently used in ecological studies.

The collected data consist of:

- numerical properties like thickness of the horizons. These were analyzed using statistical methods like determining mean values of thickness and standard deviation of recorded values within one stand;
- non numerical morphological properties like horizon designation, character of boundaries, kind of material, fabric, roots, biota and soil flora. These were described and/or scaled into classes.

Here most attention will be paid to the statistical approach to the non numerical properties.

The non numerical morphological field properties scaled in classes were converted into coded data, in order to use these as input for Twinspan. Property, class of the property (sub-property) and the horizon symbol were combined in one binary code which is related to field conditions in one of the five stands. This means for instance that a descriptive property like the form of a boundary of the F-horizon, scales into smooth, wavy, irregular or broken. The use of classed properties results in a strongly increasing number of sub-properties in the Twinspan programme.

The Twinspan programme has been used to identify relations between morphological characteristics and organic profile succession. It compares all properties with the five stands. To do so frequencies for each sub-property are calculated for each stand. This means that the initial number of site characteristics is reduced to a new set of attributes for each of the different stands. The frequences of the sub-properties are split up into three 'cutlevels': 0-25%, 26-50%, 51-100%, giving a high and stable quality of classification. The cutlevels are retrieved as 1, 2, 3 in the output of Twinspan (see figure 1). The structure of the output resembles that of the Braun Blanquet method.

Figure 1 shows a dendrogram of the output of Twinspan. At each level preferential and non preferential properties, e.g. the differentiating criteria, were determined and resulted in a split up into 7 levels. The first three levels show the ranking of the five stands. The other 4 levels show the grouping of properties within one stand.

The ranking of the stands, although obvious in the field, is done without the numerical data on the sites as well as without data on sub-properties occurring in less than three stands. This means that there are also certain morphological properties which are exclusive for one stand.

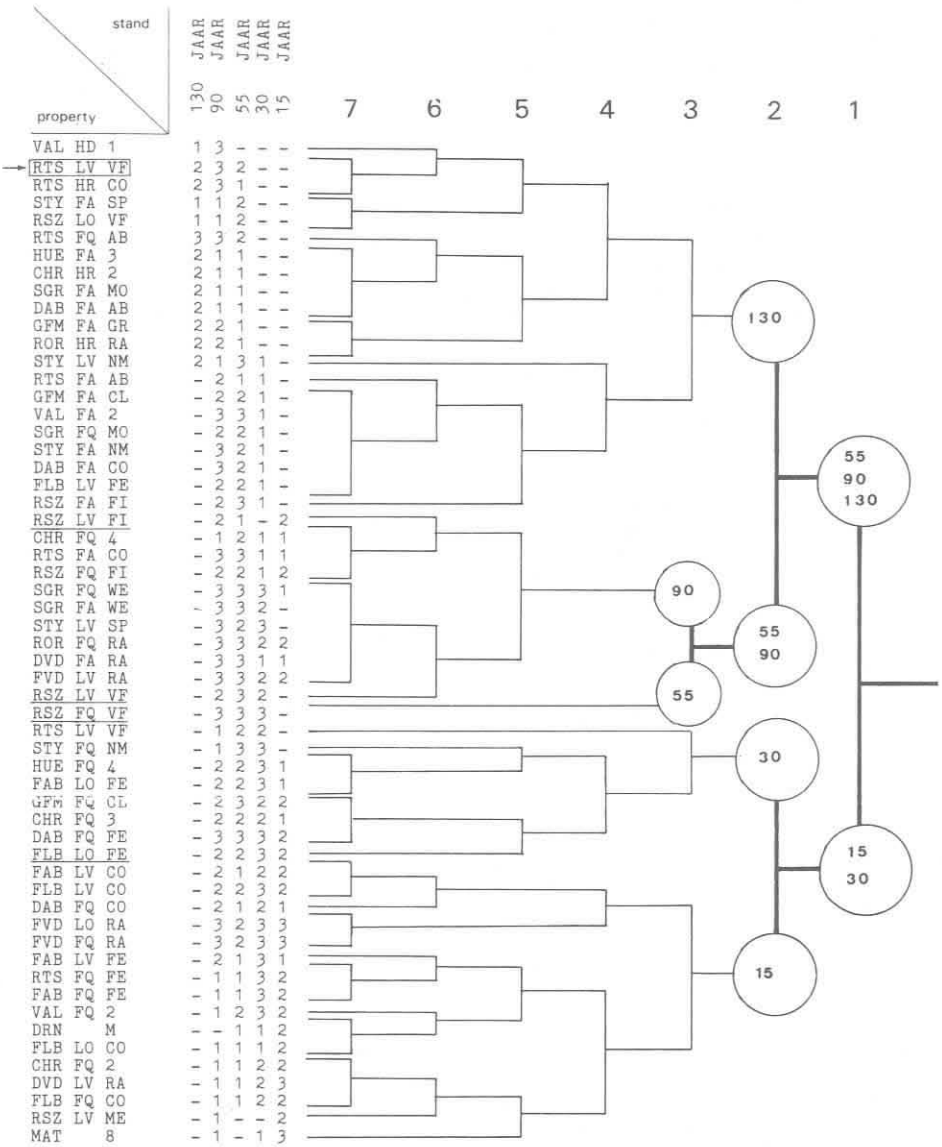
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Fig. 1. A dendrogram showing differentiating properties of the organic profile related to the different stands of Scots Pine in the Hulshorsterzand area. On the left side the codes of the properties are listed. RTS LV means that Roots abundance (RTS) in the Lv horizon in the 130 year old stand is very few (VF).

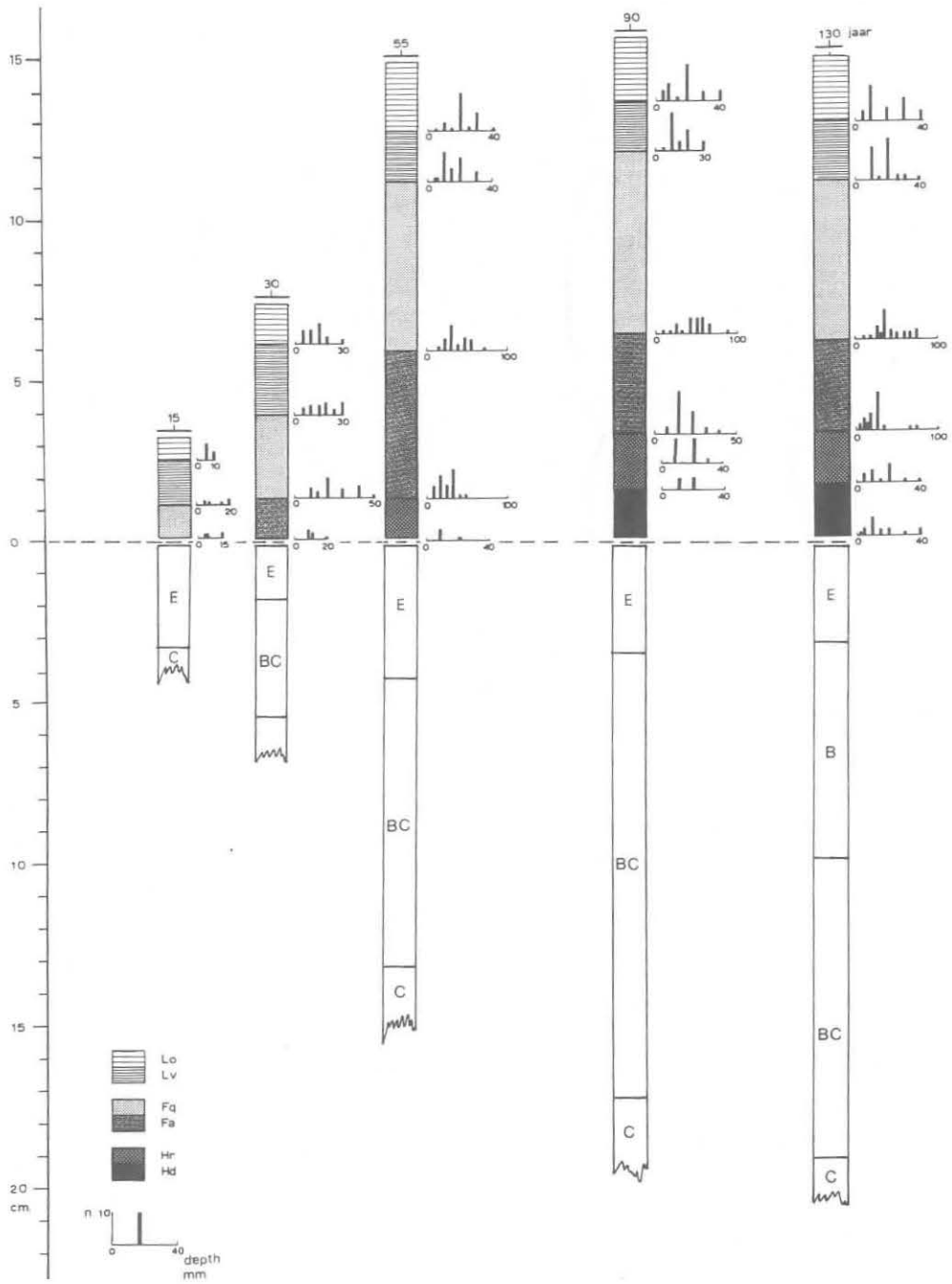

Fig. 2. Standard soil profiles including frequency diagrams of thicknesses of organic horizons for each of the Scots pine stands.

Discussion of results

The Twinspan analyses show that clear differences in non numerical properties exist between the various stands, closely related to differences in age. These results, which will not be dealt with in detail here, are in conformance with the results of the statistical analyses of the numerical properties. The latter are as follows:

The chronosequence exhibits a strong increase in thickness of the organic horizon as well as a clear differentiation in time. Soil horizon development and differentiation in the mineral profile is less pronounced and is restricted to the development of a micropodzol.

The organic profile:

In fig. 2 the "standard soil profiles" for each of the stands studied are indicated, with mean thicknesses of specific horizons within a stand. To the right the thickness of the various organic horizons at the sites studied is presented in a frequency diagram. This diagram provides essential information on the variations in thickness of the horizons within the parcels. Mean thickness of the various organic horizons is also indicated in table 1 with, in addition, the standard deviation and the number of profiles studied.

Table 1. Mean thicknesses of the organic horizons with their standard deviation of the various Scots Pine stands.
n* = number of soil profiles.

	n*	Lo	Lv	Fq	Fa	Hr	Hd
15 years	(12)	7 (3)	14 (7)	10 (6)			
30 years	(20)	13 (6)	22 (16)	26 (13)	11 (5)		
55 years	(26)	21 (8)	15 (7)	52 (23)	45 (8)	13 (5)	
90 years	(29)	20 (10)	15 (7)	56 (22)	31 (32)	17 (7)	15 (5)
130 years	(29)	20 (13)	18 (8)	49 (22)	28 (19)	16 (10)	16 (12)

The first conclusion which can be drawn is that the thickness of the organic profile strongly correlates with the age of the stand. Its strong increase from 30 to 55 years, however, needs some comments. The 15 and 30 years old stands are spontaneous pine stands, whereas the 55 years old stands has been planted. In its initial stages the latter stand had a denser tree stand and a higher biomass production, which may have resulted in a more rapid development of the organic profile. Secondly, Deschampsia flexuosa, when abundantly present as is the case in the older stands, seems to induce the development of a relatively thick organic profile.

As regards the thickness of the litter layer, equilibrium seems to be reached in about 55 years. It should be stated that in the younger soils (15 and 30 years) the thickness, compositon and bulk density (related to the composition) are quite variable, whereas in the older soils these are rather uniform.

The thickness of the fermentation layer, discontinuous in the 15 years old stand, rapidly increases with increasing age. Its considerable and rather uniform thickness in the 55 years stand is probably connected with the abundance of Dechampsia flexuosa. The slightly decreasing thickness of the F horizon in the older stands might be connected with

a lowered vitality (lower litter production) of Deschampsia with increasing age, in combination with the introduction of species with a biomass production, which is lower and/or of a different composition.

Vegetation in these older stands becomes more differentiated. Frequency distributions of thickness in the 55 and 90 years old stands are close to normal. However, in the 130 years old stand a bimodal distribution was found, strongly correlated with the rather differentiated herbal vegetation: thinner under Deschampsia and thicker under Empetrum and Vaccinium.

H horizons were first encountered, as discontinuous pockets, in the 30 years old stand. In the 55 years old stand locally a thin Hr horizon was found, mainly in pockets, but Hd horizons were not observed. In the older stands (90 and 130 years) the H horizon is continuous and its thickness only slightly increases in time. Observations in 300 years old pine stands elsewhere in The Netherlands show that equilibrium will only be reached after a very long period of time.

The mineral profile:

All soils studied are well drained and can be classified as vague soils ("duinvaaggronden").

In fig. 2 the "mean mineral profile" in the various parcels has been indicated. With respect to the horizon designation used the following needs to be stated:

- The E horizon

The drift sands contain a small amount of iron, which is present, together with a little clay, as thin coatings around the sand grains. Horizons, immediately underneath the organic profile, which lack these coatings and have a bleached appearance, have been described as E horizons. Whether iron indeed has been eluviated or is still present, but bound to organic matter, has not been established.

- The B and BC horizons

Underneath the E horizon a weakly developed B horizon is present. When having a slightly redder hue and stronger chroma than the parent material, due to slight illuviation of iron (together with organic material), but lacking soil structure, this horizon has been described as a BC horizon. In case that soil structure, although weak, is observed which is accompanied by a more distinct difference in hue and chroma, such horizon has been described as a B horizon.

Figure 2 shows that with increasing age the thickness and development of the mineral profiles increases. The thickness of the E horizon, however, hardly increases with age. Contrasts between the various horizons, not indicated in this figure, on the contrary, regularly increase with age. This indicates that the presence of an E horizon, as defined above, not necessarily implies a vertical transport of iron c.q. slight podzolisation. In fact mineral profiles with a B horizon, which represent distinct micropodzols, were only encountered in the 130 years old stand.

Conclusions

Each of the stages in a vegetation succession has a specific impact on the environment and therefore strongly determines the development and character of organic profiles. However within a stand which represents a specific succession stage the effect of other factors such as geomorphology, exposition and local vegetation becomes prominent and causes a large variability in organic profiles characteristics.

This means that it is difficult to identify those properties which characterise a specific stage within a vegetation succession.

The results show that horizon sequences together with thicknesses of individual horizons differentiate, to some degree, for soil profiles in stands of different age. For profiles with a similar horizon sequence, the Twinspan programme allows the identification of properties of individual master horizons, which characterize the individual stands.

References

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